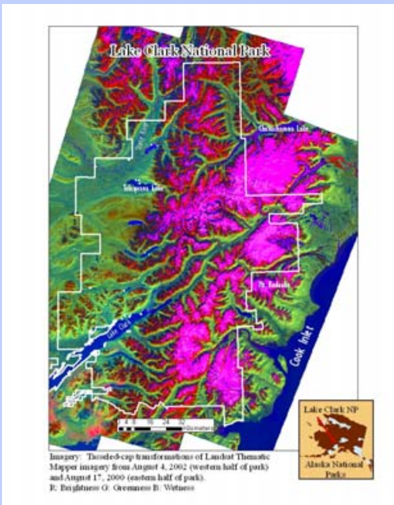
Landsat-based monitoring of vegetation in the Southwest Alaska Network (SWAN)

Robert E. Kennedy[1], Amy E. Miller[2], Warren B. Cohen[1]

[1]U.S.D.A. Forest Service, Pacific Northwest Research Station, Corvallis, OR 97331; [2] Inventory and Monitoring Program, Southwest Alaska Network, Anchorage, AK

INTRODUCTION

Monitoring landscape vegetation dynamics in the Southwest Alaska Network (SWAN) will require a combination of field and satellite-based approaches. For Lake Clark and Katmai NPP, we are testing the extent to which Landsat Thematic-mapper (TM) imagery can be used to identify and label changes in vegetation type and quality over decadal time scales.



Imagery: Tasseled-cap transformations of Landsat Thematic Mapper imagery from August 4, 2002 (western half of park) and August 17, 2000 (eastern half of park). R: Brightness G: Greenness B: Wetness

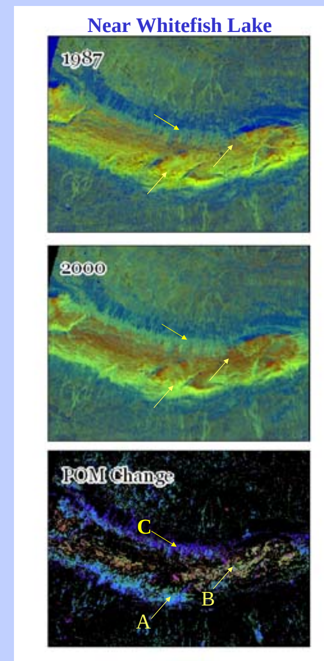
The following vegetation dynamics are of interest to the SWAN:
-- Disturbance-related loss of vegetation, including losses associated with avalanches, landslides, channel migration and floods, fires, volcanic eruptions, and insect and disease outbreaks
-- Vegetation recovery; succession
-- Encroachment of vegetation, particularly shrubs, into unvegetated areas or lichen-dominated communities

The range of desired changes challenges traditional remote sensing change detection techniques. "Hard" thematic classification approaches can describe a variety of changes, but cannot capture subtle within-type changes, nor can they easily distinguish large from moderate changes across types. Continuous-variable methods can distinguish subtle from abrupt change, but are typically tuned to a single type or direction of change, or to changes occurring within a single portion of spectral space. We are testing a "fuzzy" change detection approach in the SWAN that mixes the desirable characteristics of both thematic and continuous-variable change detection techniques.

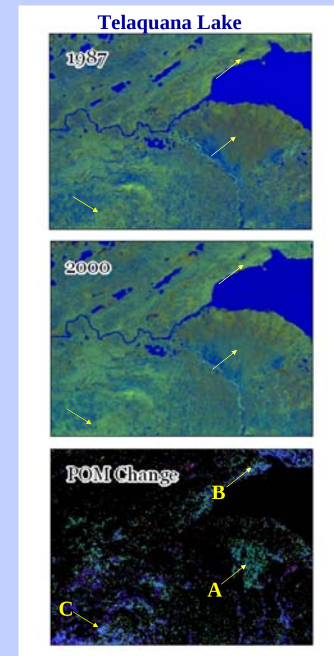
RESULTS

Moderate confidence changes: Overtopping of lichen and tundra by shrubs and trees; conversion to alder; drying of previously moist areas.

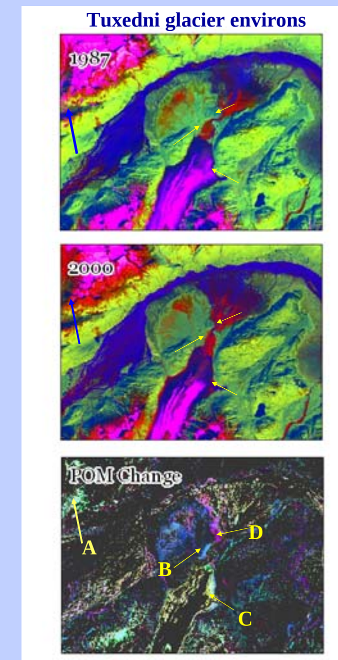
High confidence changes: Loss of snow, recovery of vegetation on bare ground, loss of vegetation during disturbance (volcanic eruptions, floods, landslides, etc.)



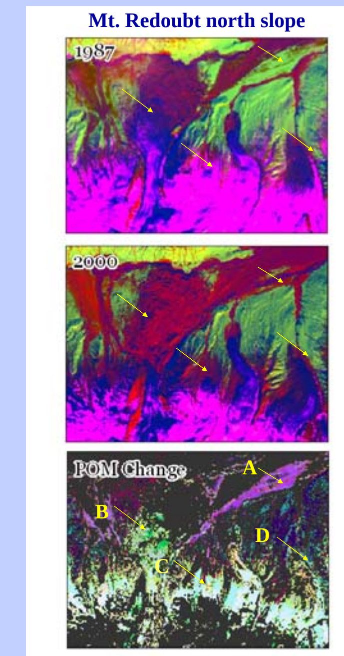
Change labels:
A: Sedge-dominated mesic tundra → Closed alder
B: Grasslands → Lichen tundra
C: Spruce woodland → Closed alder



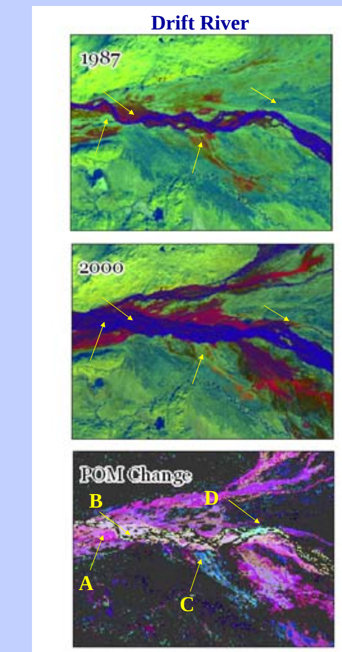
Change labels:
A: Prostrate shrub tundra → Spruce woodland
B: Sedge meadow → Closed alder
C: Sedge meadow → Closed alder



Change labels:
A: Snow → Gravel/Sparsely vegetated
B: Gravel/Sparsely vegetated → Willow shrub
C: Snow → Silty water/Dirty snow
D: Willow shrub → Gravel/Sparsely vegetated



Change labels:
A: Closed Alder → Gravel/Sparsely vegetated
B: Silty water/Dirty snow → Gravel/Sparsely vegetated
C: Snow → Gravel/Sparsely vegetated
D: Gravel/Sparsely vegetated → Sedge meadow



Change labels:
A: Closed Alder → Silty water/Dirty snow
B: Gravel/Sparsely vegetated→Silty water/Dirty snow
C: Prostrate shrub tundra → Open birch forest
D: Open birch forest → Gravel/Sparsely vegetated

METHOD

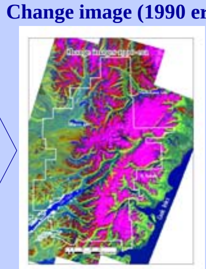
Overview of method

Our method is based on techniques developed for the North Coast and Cascades Network (NCCN; Kennedy et al. *in press*). After geometric and radiometric processing, a set of core landcover classes is identified in the data space. Gaussian probability surfaces for each core class are built in tasseled-cap spectral space for the reference image, and then applied directly to the spectral space of a "change" image from a different year. Differencing results in an image of continuous-variable change in likelihood of membership in all classes. Changes are filtered by type and magnitude of maximum pairwise likelihood of membership.

Reference image (2000 era)

Geometric and radiometric normalization

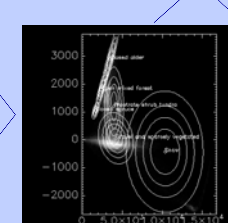
Change image (1990 era)



•Apply probability of membership (POM) to reference and change images
•Subtract change from reference
•Identify largest change pair
•Filter change > 80

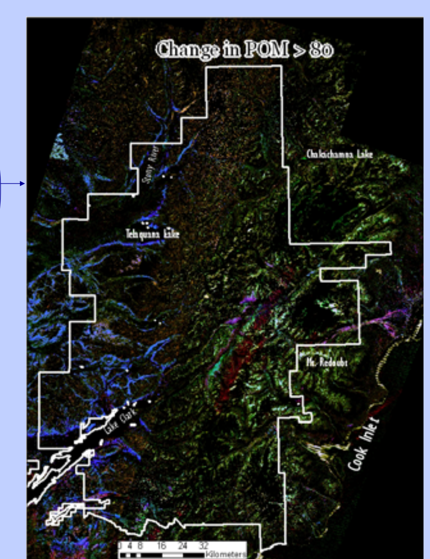
1995 Landcover

Extract Gaussian probability surfaces from selected classes



Gaussian probability surfaces

Probability surfaces



DISCUSSION

Adaptation of the NCCN probability-based change detection approach to Lake Clark National Park appears to capture changes associated with several desired vegetation dynamics.

High-confidence changes include encroachment of vegetation near the toe-slopes of retreating glaciers, removal and recovery of vegetation in riparian areas after floods and volcanic events, and conversion of snow to bare ground.

Moderate-confidence changes include in-filling of alders in existing alder patches and encroachment of alders into non-vegetated areas, overtopping of lichen by other shrub types, successional changes along gradients of increasing vegetative cover, and drying and infilling of ponds and moist tundra areas.

Changes associated with phenological and year to year variation in climate can be a potential source of uncertainty for spectral changes in herbaceous and shrub cover.

In the next phase of the project, we will explore the use of MSS and MODIS data to better separate real cover change from phenological change.

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